HATCH ASSOCIATES LTD. CONSULTING ENGINEERS CONTRACT REPORT NO 1SQ85-00133

HATCH ASSOCIATES

DEVELOPMENT OF ROTARY LEACH VESSEL TECHNOLOGY FOR THE RECOVERY OF GOLD AND SILVER BY CYANIDATION

DEPARTMENT OF SUPPLY AND SERVICES CANADA

DSS File No. 035Q-23440-5-9073
P.R.#9045.2
February 28, 1986

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MICROMEDIA

PROJECT REPORT

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

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P.R.#9045.2
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February 28, 1986

Distribution

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If you disagree with any information contained herein, please advise immediately.

1.0 SUMMARY AND CONCLUSIONS

Under contract to Supply and Services Canada, Hatch Associates Ltd., undertook investigative work in "Development of Rotary Leach Vessel Technology for the Recovery of Gold and Silver by Cyanidation". Both the rolling bottle technique and the agitated vessel system have been practiced in bench scale laboratory leaching tests for a great many years. The rotary leach vessel has not been developed for commerical operation.

The tests have demonstrated the superior efficiency of the rolling bottle system for the recovery of gold values. It also suggests significant reduction in the consumption of cyanide.

Lime consumption was slightly greater in the bottle tests. However, in overall commercial mill operations the total lime consumption is dictated by environmental considerations which usually exceeds that required for leaching.

It is evident from the results obtained in the bench scale testing that further development is warranted. We consider this should be in the form of a small pilot plant facility at an existing gold mill.

2.0 INTRODUCTION

On July 22, 1985 Hatch Associates Ltd., submitted to Supply and Services Canada a second revision of a proposal for investigative work in "Development of Rotary Leach Vessel Technology for the Recovery of Gold and Silver by Cyanidation".

Hatch Associates Ltd., on September 24, 1985 received Contract DSS File No. 03SQ.23440-5-9073. On September 30, 1985 Hatch Associates Ltd. accepted Quotation No. Q.PP-MPHM-85-53 from Ontario Research Foundation to provide up to 30 modified bottle leach tests under our direction.

Hatch Associates Ltd. arranged for the shipment from Dome Mines Limited, South Porcupine, Ontario, to the Ontario Research Foundation a one hundred and fifty pounds sample of rod mill discharge material. This sample was utilized for all the tests conducted and reported by Ontario Research Foundation. Their reports are attached as Appendices One and Two.

The details of the program, including descriptions of process concept and equipment considerations, are as outlined in Appendix Three.

3.0 TECHNICAL DISCUSSION

The ore sample for this work was the rod mill discharge from Dome Mines Limited, South Porcupine, Ontario. This product was a deliberate choice as it was known to contain approximately fifty percent of the contained gold in a form suitable for gravity separation.

3.1 Gravity Separation

Although not an item for which the subject DSS contract was issued, three of the first five bench scale tests were conducted in a rolling bottle which has been modified to provide a gold trap. This consideration is mentioned in our Proposal Item 2.4.

Assaying uncertainty, due to free gold, resulted in replacement of the modified bottle by the Ontario Research Foundation standard bottle equipment.

The Ontario Research Report on this preliminary work, Progress Report No. 1, was forwarded to you under our covering letter of January 8, 1986. A copy is attached to this report as Appendix One for purposes of record.

3.2 Shaking Table Operation

In order to duplicate the Dome Gold Mines mill circuit, and to eliminate the erratic assays due to the presence of free gold, all subsequent tests, both rolling bottle and stirrer tests, were conducted on table tailings.

The metallurgical balance for the deister shaking table operation is as follows:

Product	% Weight	Gold Assay Oz./Short Ton	% Distribution
Head	100.0	0.13	100.0
Concentrate	2.2	4.45	74.1
Tailing	97.8	0.035	25.9

The final report by Ontario Research Foundation, entitled "Comparative Gold Leaching Tests", dated February 21, 1986, is included herein as Appendix Two. All tests reported in the ORF final report were conducted on table tailing material assaying 0.035 ounces of gold per short ton as shown in the above tabulation.

3.3 Metallurgical Results

Results of bottle tests and stirrer tests are presented in Tables 1 and 2, pages 4 and 5 respectively of the Ontario Research Foundation final report, attached as Appendix Two.

All tests were conducted on table tailings material which assayed 0.035 ounces of gold per short ton. Based upon tailing assays, higher gold recovery was achieved with the rolling bottle system; only one tailing assay was as high as 0.004 ounces per ton. For comparative purposes the agitated tests resulted in four tests at 0.004, two tests at 0.005 and two tests at 0.006 ounces per ton. That is, when compared with the worst rolling bottle test, two agitated tests resulted in 2.9 percent lower gold recovery and two other agitated tests resulted in 5.7 percent lower gold recovery.

Conclusions

From the viewpoint of gold recovery the superior efficiency of the rolling bottle system has been demonstrated.

3.4 Dissolved Oxygen Studies

The Dissolved oxygen content in parts per million is reported in the ORF report, pages 6 and 7, attached as Appendix Two.

For comparative purposes it can be stated that in all the rolling bottle tests the dissolved oxygen content reached 9 ppm after four hours elapsed time; one stirrer test only reached this level of dissolved oxygen after sixteen hours elapsed time. The range of dissolved oxygen readings have been plotted and are presented in the form of a graph (see Figure 1).

Twenty-four hour tests were conducted by both leaching methods with dissolved oxygen readings taken every two hours. The rolling bottle tests reached 9 ppm within two hours elapsed time; the stirred vessel required sixteen hours to reach the same level.

The possibility exists that different ambient temperatures may have had some bearing on the above observations. The Ontario Research Foundation final report, attached as Appendix Two, presents the following statement on Page Three: "The dissolved oxygen readings indicate, that in both bottle and agitated tests, the oxygen saturation point is reached after a maximum of 4 hours. Differences in the dissolved oxygen levels between the bottle and agitated tests after the saturation point has been reached, are most likely due to temperature differences. Variation in the oxygen readings for any single test, again are due to temperature variations. At ORF the temperature is allowed to drop during the night. This would account for higher dissolved oxygen readings, as the saturation point rises with a decrease in temperature.

Conclusion

Oxygen is initially dissolved much more quickly in the rolling bottle tests than it is in the agitated tests. At the point of saturation of the slurry with oxygen, both systems have been demonstrated to be of equal efficiency.

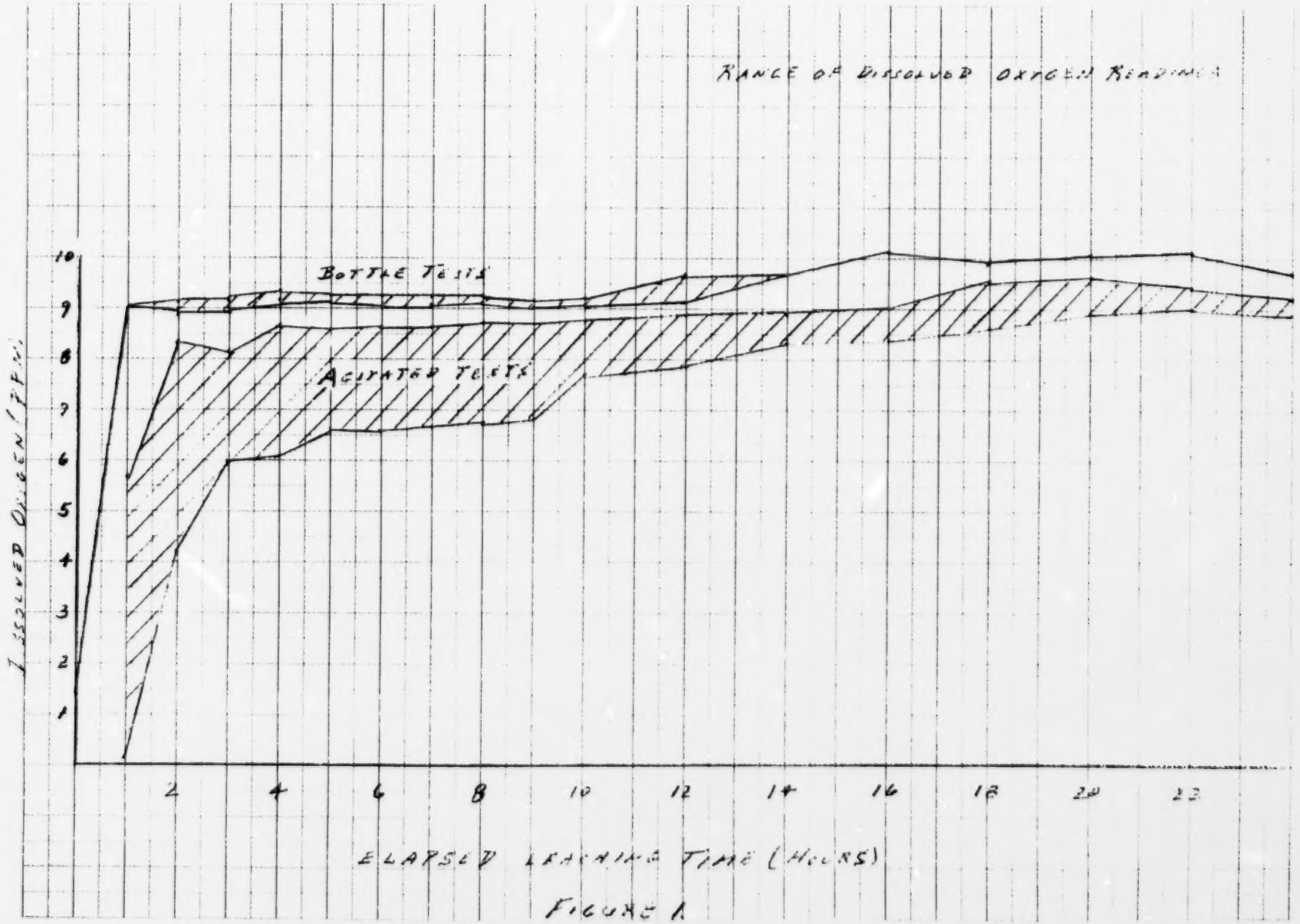
RANGE OF DISSOLVED OXYGEN READINGS
BOTTLE TESTS
AGITATED TESTS
DISSOLVED OXYGEN (PPM)
10
9
8
7
6
5
4
3
2
1
2
4
6
8
10
12
14
16
18
20
22
ELAPSED REACTING TIME (HOURS)

FIGURE 1

3.5 Reagent Consumption

The consumption of cyanide and lime during the first 7 comparative tests, which were eight-hour leaching periods, are tabulated as follows:

Bottle Tests			Agitated Tests		
Test No.	$NaCN$ Kg/T	$CA(OH)_2$ Kg/T	Test No.	$NaCN$ Kg/T	$CA(OH)_2$ Kg/T
HB-1	0.86	0.34	HS-1	1.27	0.24
HB-2	0.99	0.29	HS-2	1.08	0.16
HB-3	0.85	0.28	HS-3	1.10	0.16
HB-4	1.30	0.23	HS-4	1.08	0.29
HB-5	0.97	0.38	HS-5	1.54	0.21
HB-6	1.25	0.43	HS-6	1.51	0.12
HB-7	--	--	HS-7	1.41	0.11

It is of particular interest to observe that the cyanide consumption is lower and the lime consumption is higher in the bottle tests than in the agitated tests.

The lower cyanide consumption is much desired, both from the economic and environmental viewpoint. The lime consumption, during leaching, is of minor economic importance as additional lime is usually required following leaching for tailings settling and protective alkalinity for safety and environmental considerations.

3.6 Flowsheet Considerations

For reasons of availability of ORF personnel and some unanticipated delays due to new equipment design and fabrication, some variables remain to be studied. These include the following:

(a) Pulp Density: All tests were conducted at fifty percent solids - not necessarily optimim.

(b) Bottle R.P.M.: All tests were conducted at fifty R.P.M. possibly excessive speed and not necessarily optimum.

(c) Reagent Dosage: Solution strength was constant at 0.2 percent N_aC_n - not necessarily optimum.

(d) Power Consumption: An indication of consumed power was not obtained. Consumed power figures could be misleading until such time as (a) and (b) are known to be optimum; both will influence power drawn.

4.0 TECHNICAL BENEFITS OF ROTARY LEACH VESSELS

The successful completion of this phase of the project has confirmed the premise upon which the proposal was originally submitted for consideration. That is that the rotary leach vessel method of cyanidation exhibits equal efficiency to the agitated leach method and strong indications are presented which lead to the thought that the rotary leach method is superior.

4.1 Increased Gold Recovery and Lower Reagent Consumption

The generally accepted chemical equation for the dissolution of gold in cyanide solutions is as follows:

$$4\ Au + 8\ NaCn + O_2 + 2\ H_2O = 4\ NaAu + 4\ Na\ OH$$

It is claimed in Item 3.4 of this report that the dissolved oxygen point of saturation is reached much more quickly by the rotary leach method.

It is claimed in Item 3.5 of this report that the cyanide consumption is lower when gold dissolution is effected by the rotary leach method.

4.2 Power Requirements

Conventional leach agitators, using turbines similar to ships' impellers for mixing, are high power consumers and additional power is required to compress air for sparging beneath the impellers.

Commercial Rotary Leach Vessels would require power to provide slow rotation through tires on which they would be supported and driven. Substantially lower power draft is anticipated, contributing to decreased operating costs.

4.3 Settling of Free Gold

Conventional agitators are usually started up on waste rock or low grade ore because material does build up to form a tank bottom configuration dictated by the flow pattern caused by the mixer. This build-up is notorious for trapping free gold which is not recovered until the leach vessel is out of service for repairs or milling is terminated.

Build-up would not be probable in Rotary Leach Vessels, but should it occur it would be visible as the shell emerges from the pulp during rotation.

4.4 Gravity Separation

Most gold mills use jigs, shaking tables, settling cones or some type of gravity separation unit in the grinding circuit. This is to remove free gold before it is allowed to enter the agitators and settle to the bottom. Also, larger gold particles require longer retention time for leaching.

It is anticipated that gold traps could be built into the discharge end of the shell of rotary leach vessels to act in place of gravity separation equipment. This concept was considered in the testwork reported herein, and a rolling bottle was designed and fabricated. However, preliminary tests revealed inadequate design and this equipment was replaced by the conventional rolling bottle, in order to pursue the basic premise of oxygen dissolution, and therefore more efficient Au, Ag dissolution and reduced reagent consumption (see 4.1).

4.5 Action During Power Failure

Conventional agitators usually can be re-started after power failure, provided the power outage is of short duration. However, every power failure adds to the build-up in the tank bottom as mentioned it Item 4.3 above.

Rotary Leach Vessels could settle out during power failures and still be started readily by rocking with the drive motor on-off push button.

4.6 Rotary Leach Vessels for Carbon in Pulp Circuits

Conventional C.I.P. circuits utilize separate vibrating screens or integral stationary screens for carbon advance and removal.

Since Rotary Leach Vessels are suitable for discharging to trommel screens, and it is likely that rotation will be quite slow, there appears to be a good possibility that carbon abrasion would be minimal. Also, one would expect minimal screen blinding, lower maintenance, and an overall increase in circuit efficiency.

APPENDIX ONE

ONTARIO RESEARCH

November 19, 1985

Mr. H. G. McVeigh
Hatch Associates Ltd.
21 St. Clair Avenue East
Toronto, Ontario
M4T 1L9

Dear Mr. McVeigh:

Subject: Comparative Gold Leaching Tests
Your P.O. No P-2784
Our Account No. 41-10487

Enclosed is a revised Progress Report No. 1 that includes the results of 2 additional tests (No. 2A and 2B) conducted on October 29th where Mr. A. E. Lamping was present to observe the dissolved oxygen measurement and test procedures. It also includes corrections on head sample assay results and supersedes the initial report dated October 24, 1985.

Yours truly,

V. I. Lakshmanan
Manager, Mineral Processing
and Hydrometallurgy Groups
Materials Division

VIL/lw

cc: Mr. J. Hemstock
Enclosure

Account No. 41-10487

Progress Report No. 1

Comparative Gold Leaching Tests

for

Hatch Associates Ltd.
21 St. Clair Avenue East
Toronto, Ontario
M4T 1L9

A. Marascio
V. I. Lakshmanan
November 19, 1986

RESEARCH

SHERIDAN PARK RESEARCH COMMUNITY

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1.0 INTRODUCTION

Based on ORF Quotation No. Q.PP-MPHM-85-53 dated September 10, 1985, Hatch Associates Ltd. (Mr. H. G. McVeigh) accepted and authorized a project for a series of comparative gold cyanidation tests to be conducted on a sample of rod mill discharge from Dome Mines Limited.

Following some earlier meetings, the project objectives and test procedures were further discussed between Mr. J. Hemstock, Consulting Metallurgist, Hatch Associates Ltd. and members of ORF pilot plant staff (Dr. V. I. Lakshmanan and J. Melnbardis) on October 7, 1985. Mr. Hemstock confirmed the discussions and outlined test objectives in a letter dated October 9, 1985.

The work was authorized by Mr. H. G. McVeigh under P.O. No. P-2784.

This report describes the procedures and results of the initial work conducted during October.

2.0 TEST PROCEDURES AND RESULTS

2.1 HEAD SAMPLE AND FEED BATCH PREPARATION

The feed sample of rod mill discharge was received from Dome Mines Limited in September. The net wet weight of pulp in two containers totalled 72.5 kg (160 lbs).

The supernatant water and some slime was decanted, filtered and the small amount of the resulting filter cake was recombined with the bulk sample by quartering. The dewatered pulp was then apportioned into 42 x 1500 g batches by riffling using a 0.46m (2.5 cm slot) riffler. The riffled individual batches and a 2.25 kg remainder totalling 65.25 kg are being stored in sealed plastic bags. The

indicated moisture content of the feed following riffling is 10.0% (1350 - 1355 g dry weight per batch).

One of the riffled batches was dried and prepared to obtain a head sample for assay and structure determination. The results are shown in Tables 1 and 2.

2.2 GRINDING

A 19 cm dia. x 25 cm long rod will with a 10 kg graded rod charge has been designated to be used for this project only.

Three initial batches of feed were ground at 67% pulp solids density for 60, 40 and 30 minutes. The 30 minute grind yielded 84.1% passing 200 mesh product and as a result the 30 minute grind has been established to produce the required test product structure.

2.3 CYANIDATION AND DISSOLVED OXYGEN TESTS

Five preliminary 24 hour cyanidation tests were carried out using a rolling bottle (18 cm dia. 50 r.p.m.) and a 2 L impeller agitated pyrex reactor kettle. Tests A and B were run in parallel to be directly comparable. Test 1AR was a repeat test of 1A. The test data and results are shown in Tables 3 and 4.

The feed pulp of each test after washing from the rod mill was filtered using a 0.2 m dia. Booth pressure filter. The filtrate was saved and part of it used to reconstitute the filter cake to the required 50% pulp solids density for cyanidation.

A Yellow Springs Instrument Company - YSI Model 54 oxygen analyser is presently available for the dissolved oxygen determinations during cyanidation.

Tests 2A and 2B were conducted on October 29th when Mr. A. E. Lamping of Hatch Associates Ltd. was present to review the test procedures.

V. I. Lakshmanan
Manager, Mineral Processing
and Hydrometallurgy Groups
Materials Division

A. Marascio
Technologist
Materials Division

TABLE 1

HEAD SAMPLE AND GROUND BATCH ASSAYS

	Gold	
	oz/ton	g/mT
Head Sample	0.11	3.77
Ground Batch 1	0.068	2.33
Ground Batch 2	0.16	5.48
Ground Batch 3	0.065	2.23

TABLE 2

HEAD SAMPLE (AS RECEIVED FEED) STRUCTURE

	WEIGHT %	
Mesh	Retained	Cum. Passing
6	0.8	99.2
8	1.5	97.7
12	7.0	90.7
14	3.8	86.9
20	10.6	76.3
28	10.8	65.5
35	10.0	55.5
48	8.4	47.1
65	5.4	41.7
100	4.4	37.3
100	5.4	31.9
200	4.0	27.9
200	27.9	

TABLE 3

CYANIDATION DATA AND RESULTS

Test No	Pulp Agitation Means	Pulp pH	Tailings (24 hrs) Assay Au (oz/ton)	Gold in Solution Recovery (%) *	Reagent Consumption -kg/m NaCN	$Ca(OH)_2$
1 A	Rolling Bottle	11.7	0.059	54.6	1.77	0.65
1 B	Impeller Agitation	11.7	0.009	93.1	3.04	0.64
1AR	Rolling Bottle (Repeat 1A)	11.7	0.038	70.8	1.69	0.66
2 A	Rolling Bottle	11.0	0.050	61.5	1.47	0.46
2 B	Impeller Agitation	11.0	0.075	42.3	3.02	0.45

All Tests: 24 hour leaching time at 50% pulp solids density with calcium hydroxide for pH control and sodium cyanide added at 1g/L of leach solution.

* Based on feed assaying 0.13 oz/ton as reported by Dome Mines Ltd.

TABLE 4

DISSOLVED OXYGEN CONTENT OF CYANIDATION PULP

Test No. Cyanidation Time - Hrs.	Rolling Bottle Tests			Impeller Agitated Tests	
	1 A	1 AR	2 A	1 B	2 B
	Oxygen - ppM				
0	1.1	1.0	1.0	1.1	1.0
1	2.4	2.6	2.5	1.2	0.1
2	8.1	6.9	8.9	1.2	0.7
3		7.8	9.6		0.2
4		8.7	10.0		2.8
5		9.5	10.1	1.7	4.9
6	10.0	10.0	9.6		6.0
7		10.2	9.5		7.1
8		10.0	9.3		7.1
9		9.6	9.3		7.4
10		8.9	9.3		7.5
11			9.3		7.9
12			9.2		8.1
13			9.2		8.3
14			9.1		8.4
15			9.1		9.6
16			9.0		9.7
17			8.9		9.5
18				3.1	
19	7.2				
24	6.1	8.1	8.8	9.1	8.2

FIGURE I

DISSOLVED OXYGEN vs. CYANIDATION TIME

October 24, 1985

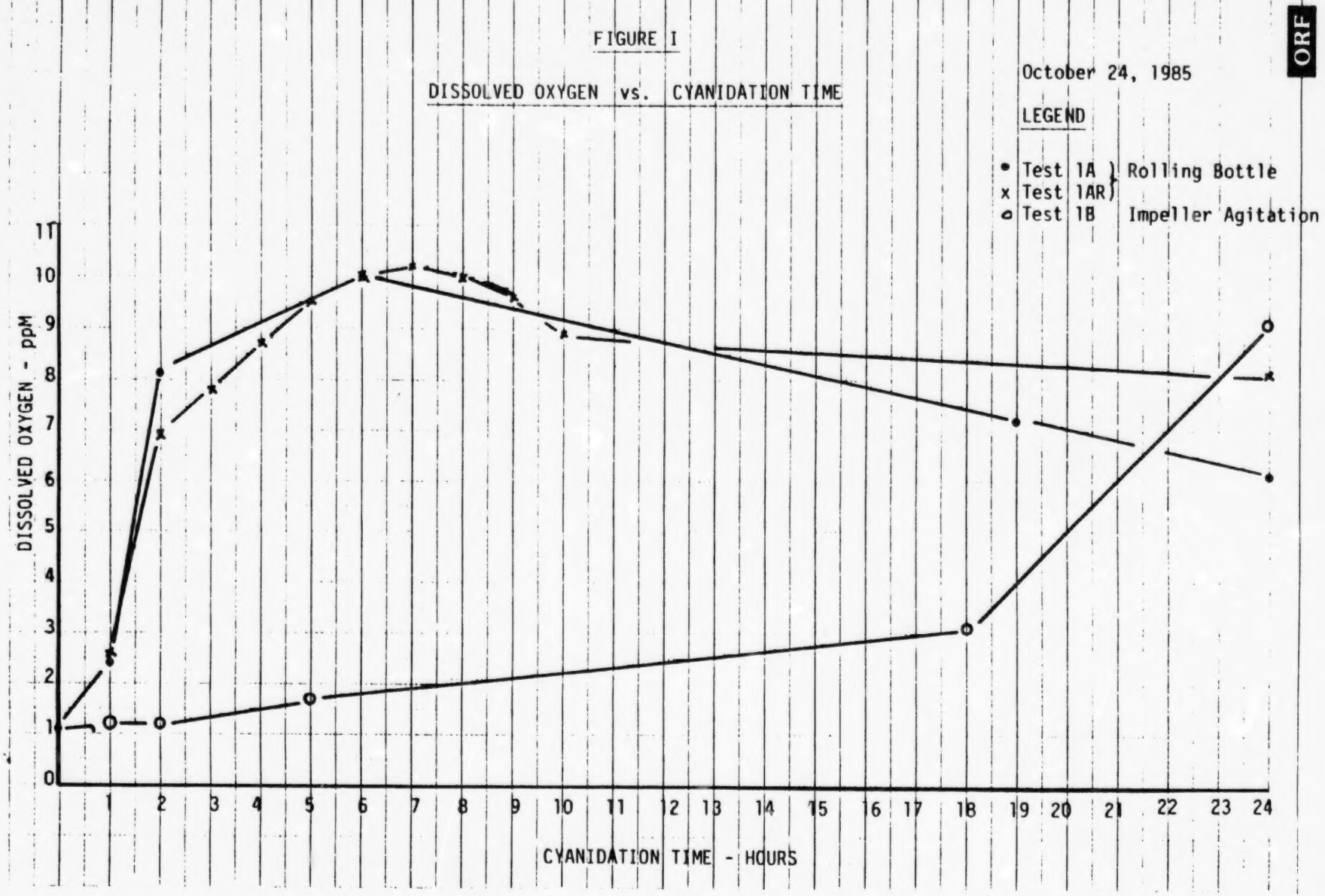


FIGURE II

DISSOLVED OXYGEN vs. CYANIDATION TIME

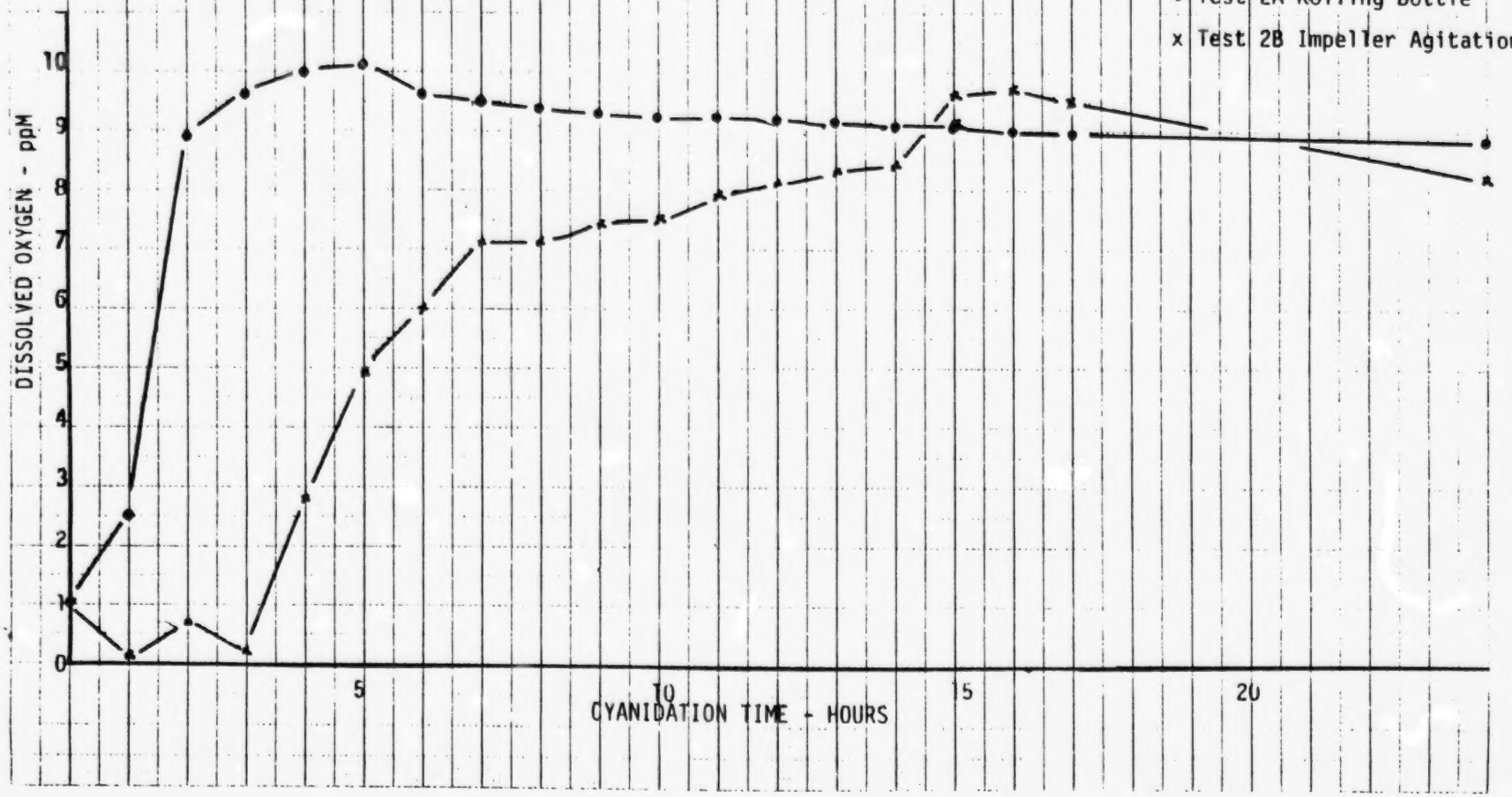
October 29, 1985

ORF

LEGEND

• Test 2A Rolling Bottle

x Test 2B Impeller Agitation



APPENDIX TWO

CONTRACT No. 41-10487

FINAL REPORT

COMPARATIVE GOLD LEACHING TESTS

for

Hatch Associates Ltd,
21 St. Clair Avenue East
Toronto, Ontario
M4T 1L9

V.I. Lakshmanan
J. Biskupski
Materials Division

February 21,1986

RESEARCH

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1. Introduction

Based on O.R.F. Quotation No. Q.PP-MPHM-85-53 dated September 10, 1985, Hatch Associates Ltd. (Mr. H.G. McVeigh) accepted and authorized a project for a series of comparative gold cyanidation tests to be conducted on a sample of rod mill discharge from Dome Mines Limited.

Following some earlier meetings, the project objectives and test procedures were further discussed between Mr. J. Hemstock, Consulting Metallurgist, Hatch Associates Ltd. and members of O.R.F. pilot plant staff (Dr. V.I. Lakshmanan and J. Melnbardis) on October 7, 1985. Mr Hemstock confirmed the discussions and outlined test objectives in a letter dated October 9, 1985.

The work was authorized by Mr. H.G. McVeigh under P.O. No. P-2784.

Initial testwork was conducted on the rod mill discharge ground to +80% -200 mesh. The testwork was reported in Progress Report No. 1 on November 19, 1985. It was found that the presence of free gold in the rod mill discharge led to irregular gold values in the batch samples and cyanidation tailings. Consequently the rod mill discharge was tabled after grinding and the table tailings used as cyanidation feed.

The final report lists the results from bottle and stirred vessel cyanidation tests conducted on the table tailings.

2. Test Procedure and Results

2.1 Grinding

A 19 cm diameter x 25 cm long rod mill with a 10 kg graded rod charge was used. Grinding time was 30 minutes, as established in the initial testwork.

Fourteen batches of 1500 gr (wet) were ground for tabling.

2.2 Tabling

Tabling was on a Deister table. The testfeed was as a thickened mill discharge with washwater as required. Two products were recovered, a concentrate, appearing to consist of mainly sulfides and a sand and slimes tailing. The metallurgical balance of the tabling was:

Product	Wt%	Au oz/t	Au Distr. %
Head	100.0	0.13	100.0
Conc.	2.2	4.45	74.1
Tls.	97.8	0.035	25.9

* Calculated

The concentrate was dried and assayed, the tailings were filtered and after thorough blending stored in plastic bags for subsequent cyanidation. A sample of the tailings was dried for moisture determination and assay.

2.3 Cyanidation

Twenty 24 hour and two 12 hour cyanidation tests were carried out, using Dome table tailings as testfeed. Twelve 24 hour tests and one 12 hour test were impeller agitated and eight 24 hour tests and one 12 hour test were in a rolling bottle.

The impeller agitation was at 400 RPM. Rolling tests at 50 RPM. All tests were at 50% solids. Solution strength was at 0.2% NaCN. The 12 hours tests were sampled at 4, 8 and 12 hours.

The test results and reagent consumptions are listed in Table 1 and 2.

The dissolved oxygen of the slurries was measured using a Yellow Springs Instrument Co. YSI Model 57 oxygen analyser. Readings were at hourly intervals to 8 hours in most tests. Three tests were monitored for 24 hours at 2 hour intervals.

The dissolved oxygen measurement are shown in Table 3 and 4. All cyanidation tests resulted in residues assaying less than 0.01 oz/t gold. The 12 hour tests showed cyanidation to be complete after 12 hours, with the residues assaying 0.03 oz/t Au. At 8 hours the solids assayed 0.005 and 0.006 oz/t Au. The reagent consumption and results are shown in Table 5 and 6.

The dissolved oxygen readings indicate, that in both bottle and agitated tests, the oxygen saturation point is reached after a maximum of 4 hours. Differences in the dissolved oxygen levels between the bottle and agitated tests after the saturation point has been reached, are most likely due to temperature differences. Variation in the oxygen readings for any single test, again are due to temperature variations. At O.R.F. the temperature is allowed to drop during the night. This would account for higher dissolved oxygen readings, as the saturation point rises with a decrease in temperature. Table 7 shows the saturation - temperature relationship for oxygen in fresh water.

3. Recommendations

It is recommended that future work be carried out using a higher grade test material. The material should contain other minerals that will produce slightly reducing conditions in the cyanidation slurries.

V.I.Lakshmanan, Ph.D.
Manager
Mineral Processing and
Hydrometallurgy Groups

J. Biskupski
Technologist

Table 1

RESULTS OF BOTTLE TESTS

Test No.	Testfeed	NaCN kg/T	$Ca(OH)_2$ kg/T	Au oz/t Head	Au oz/t Residue	Au Rec. %
HB-1	Dome Table Tls. 30 min. Gr	0.86	0.34	0.035	0.003	91.4
HB-2	Dome Table Tls. 30 min. Gr	0.99	0.29	0.035	0.003	91.4
HB-3	Dome Table Tls. 30 min. Gr	0.85	0.28	0.035	0.002	94.3
HB-4	Dome Table Tls. 30 min. Gr	1.30	0.23	0.035	0.002	94.3
HB-5	Dome Table Tls. 30 min. Gr	0.97	0.38	0.035	0.003	91.4
HB-6	Dome Table Tls. 30 Min. Gr	1.25	0.43	0.035	0.003	91.4
HB-7	Dome Table Tls. 30 Min. Gr	-	-	0.035	0.004	88.6
HB-8	Dome Table Tls. 30 Min. Gr	1.34	0.37	0.035	0.003	91.4

Table 2

Results of Stirrer Tests

HS-1	Dome Table Tls. 30 min. Gr	1.27	0.24	0.035	0.006	82.9
HS-2	Dome Table Tls. 30 min. Gr	1.08	0.16	0.035	0.004	88.6
HS-3	Dome Table Tls. 30 min. Gr	1.10	0.16	0.035	0.005	85.7
HS-4	Dome Table Tls. 30 min. Gr	1.08	0.29	0.035	0.002	94.3
HS-5	Dome Table Tls. 30 min. Gr	1.54	0.21	0.035	0.004	88.6
HS-6	Dome Table Tls. 30 Min. Gr	1.51	0.12	0.035	0.003	91.4
HS-7	Dome Table Tls. 30 Min. Gr	1.41	0.11	0.035	0.004	88.6
HS-8	Dome Table Tls. 30 Min. Gr	1.25	0.10	0.035	0.003	91.4
HS-9	Dome Table Tls. 30 Min. Gr	1.55	0.28	0.035	0.006	82.9
HS-10	Dome Table Tls. 30 Min. Gr	1.39	0.21	0.035	0.002	94.3
HS-11	Dome Table Tls. 30 Min. Gr	1.68	0.18	0.035	0.005	85.7
HS-12	Dome Table Tls. 30 Min. Gr	0.91	0.17	0.035	0.004	88.6

Table 3

DISSOLVED OXYGEN CONTENT (ppm) CYANIDATION PULPS

BOTTLE TESTS

TEST

Time/ Hrs.	1A	1AR	2A	H.B.1	H.B.2	H.B.3	H.B.4	H.B.5	H.B.6	H.B.7	H.B.8	H.B.9
0	1.1	1.0	1.0	1.45								
1	2.4	2.6	2.5	9.0	8.8	8.8	8.8	8.8	8.8	9.0		
2	8.1	6.9	8.9	9.1	9.0	9.0	9.0	8.8	9.0	9.1	9.1	9.2
3		7.8	9.6	8.95	9.0	9.0	9.1	8.8	9.0	9.1		
4		8.7	10.0	9.2	9.1	9.0	9.0	9.0	9.1	9.1	9.4	9.1
5		9.5	10.1	9.1	9.0	9.0	9.0	9.2	9.1	9.1		
6	10.0	10.0	9.6	9.1	9.0	9.1	9.0	9.2	9.1	9.0	9.2	9.1
7		10.2	9.5	9.1	9.1	9.0	9.0	9.2	9.1	9.1		
8		10.0	9.3	9.1	9.0	9.0	9.0	9.1	9.1	9.1	9.2	9.1
9		9.6	9.3									
10		8.9	9.3								9.2	9.1
11			9.3									
12			9.2								9.7	9.1
13			9.2									
14			9.1								9.7	
15			9.1									
16			9.0								10.1	
17			8.9									
18											9.9	
19	7.2											
20											10.1	
21												
22											10.1	
23												
24	6.1	8.1	8.8	9.2	9.0	9.0	9.0	9.5	9.3	9.2	9.7	

Table 4

DISSOLVED OXYGEN CONTENT (ppm) CYANIDATION PULP

STIRRER TESTS

ime/ s.	H.S.1	H.S.2	H.S.3	H.S.4	H.S.5	H.S.6	H.S.7	H.S.8	H.S.9	H.S.10	H.S.11	H.S.12	H.S.13
	0.1	0.4	0.95	0.8	2.3	3.2	5.8	3.2	1.2	2.8			
	4.2	5.2	6.5	6.7	5.9	6.2	6.6	6.9	6.2	6.2	5.9	6.0	8.4
	6.0	6.5	7.8	7.5	7.7	7.7	7.65	8.1	7.6	7.35			
	6.1	6.6	8.0	8.0	8.0	8.1	7.85	8.3	7.7	7.8	6.4	7.75	8.7
	6.7	6.75	8.05	8.2	8.0	8.2	8.15	8.6	7.7	8.0			
	6.6	6.8	8.3	8.1	8.5	8.3	8.4	8.5	8.0	8.0	6.95	8.35	8.7
	6.6	6.7	8.35	8.5	8.5	8.5	8.5	8.6	8.0	8.2			
	6.7	6.9	8.1	8.6	8.6	8.5	8.5	8.5	8.15	8.35	7.35	8.65	8.7
	6.8	6.9	8.3	8.7									
0											7.7	8.75	8.7
1													
2											7.9	8.85	8.6
3													
4											8.3	8.95	
5													
6											8.4	9.0	
7													
8											8.6	9.1	
9													
0											8.9	9.6	
1													
2											9.0	9.4	
3													
1	7.8	7.9	8.3	8.7	8.8	8.7	8.8	8.75	9.2	8.8	8.9	9.2	

Table 5

RESULTS OF BOTTLE TESTS

Test No.	Testfeed	NaCN Kg/t	$Ca(OH)_2$ Kg/t	Au oz/t Head	Au oz/t Residue	Au Rec. %
H-B-9	Table Tailings			0.035		100.0
	4 hours	0.86	0.29		N.A.	
	8 hours	1.02	0.32		0.006	82.9
	12 hours	1.39	0.37		0.003	91.4

Table 6

RESULTS OF STIRRED TESTS

Test No.	Testfeed	NaCN Kg/t	$Ca(OH)_2$ Kg/t	Au oz/t Head	Au oz/t Residue	Au Rec. %
H-S-13	Table Tailings			0.035		100.0
	4 hours	0.70	0.16		N.A.	
	8 hours	1.29	0.26		0.005	85.7
	12 hours	1.45	0.36		0.003	91.4

Table 7

SOLUBILITY OF OXYGEN IN FRESH WATER

Temperature °C	Mg/L Dissolved Oxygen	Temperature °C	Mg/L Dissolved Oxygen
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.05
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.31
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

Source: Derived from 15th Edition "Standard Methods for the Examination of Water and Wastewater."

APPENDIX THREE

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH ASSOCIATES

21 St. Clair Ave. East
Toronto, Ontario M4T 1L9, Canada
Telephone (416) 962-6350
Telex 065-24315

July 22, 1985

Supply & Services Canada
11C1 Place du Portage
Phase III
11 Laurier Street
Hull, Quebec
K1A 0S5

Attention : Dr. R.G. Agarwal
Senior Science Procurement Officer
Science Branch
Science & Professional Service Directorate

Dear Sir:

Your File Reference : 06SQ.23440-5-9073

Our Reference : Hatch Associates Ltd.
Proposal No. P.T. 936 (Rev.) dated June 25, 1985

In response to your letter and attachments of June 4, 1985 we are pleased to transmit three copies of a second revision to our proposal for investigative work in "Development of Rotary Leach Vessel Technology for the Recovery of Gold and Silver by Cyanidation".

We are called on to work continually in various ore testing facilities, and you will note that we have selected the Ontario Research Foundation as the venue for this work. This has the advantage of keeping our travel time and expense to a minimum during the duration of the program. We are well acquainted with their research personnel and testing facilities.

We believe our submission is now complete, but should any additional information be required, we will be pleased to provide it.

Yours very truly,

H.G. McVeigh, P. Eng.
Senior Consultant

HGMcV:rlr
Attachments

HATCH ASSOCIATES LTD.

ENGINEERS INGÉNIEURS

UNSOLICITED PROPOSAL

FOR

SUPPLY AND SERVICES CANADA

"DEVELOPMENT OF ROTARY LEACH VESSEL TECHNOLOGY FOR THE RECOVERY OF GOLD AND SILVER BY CYANIDATION"

July 22, 1985
P.T. 936 (Rev. II)

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1.0 INTRODUCTION AND BACKGROUND OF PROPOSAL

This proposal presents a new process and equipment concept for the recovery of gold and silver from ores by cyanidation.

An entirely new type of leach vessel is considered and preliminary work is proposed to establish design criteria and process operating parameters. The possibilities of achieving commerical utilization warrant this study with a view to increasing the efficiency of gold and silver recovery from Canadian ores. In addition, Canadian equipment manufacturers would be in position to present rotary leach vessel technology to the world market.

1.1 Leaching Vessels for Cyanidation of Gold and Silver Ores

Historically, leaching vessels have been large tanks containing the finely ground ore referred to as "slurry" or "pulp", usually about fifty percent solids by weight. These tanks are either mechanically agitated or stirred by compressed air injection, in which case they are called Pachuca Tanks.

In recently designed facilities the Pachucas have largely been superceded by mechanically agitated tanks, usually with low pressure air sparged into the bottom area of the tanks.

Oxygen, from the air provided, is required for the dissolution of gold in cyanide solutions. The chemical equation for dissolution is generally accepted to be as follows:

$$4\ Au + 8\ NaCn + O_2 + 2\ H_2O = 4\ NaAu\ (Cn)_2 = 4\ NaOH$$

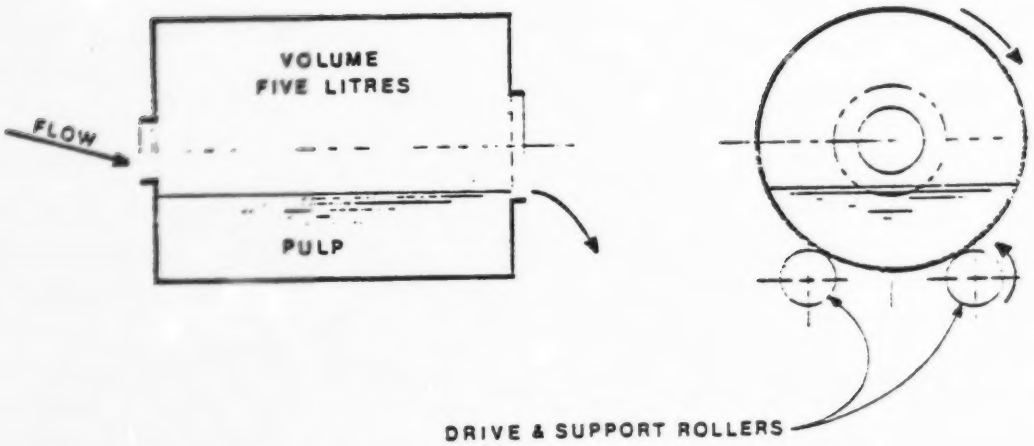
1.2 Bench Scale Investigations of Gold and Silver Cyanidation

When it is desired to test the response of a new gold or silver ore sample to conventional cyanidation practice, most laboratories use the "Rolling Bottle" method or the "Agitated Beaker" method or both. The former consists of placing the pulp sample, with cyanide and lime added to the pulp, in a bottle and simply placing the bottle horizontally on a set of rotating rollers designed to keep the bottle rolling slowly. The "Agitated Beaker" method utilizes a mechanical mixer in a beaker and usually air is blown in under the mixer.

This proposal is prompted by the fact that when both methods are used on the same sample material, the "Rolling Bottle" method results in higher gold recovery and lower reagent consumption. No commercial vessel has been developed to simulate the greater efficiency of the Rolling Bottle method. It is proposed to study the reasons for the greater efficiency with a view to investigating the possibilities of better technical and economic results using the proposed rotary leach vessels.

1.3 Configuration of Proposed Rotary Leach Vessel

The laboratory bench-scale unit, as envisaged at this time, will consist of a short section of ABS pipe and will be suitable for rolling on an existing bottle-rolling mechanism.



2.0 TECHNICAL AND ECONOMIC BENEFITS OF ROTARY LEACH VESSELS

2.1 Increased Gold Recovery and Lower Reagent Consumption

It is not known why the Rolling Bottle method is more efficient than the Agitated Beaker method, although it may be a result of thin film activity because the wetted area is exposed to the atmosphere during more than half of the rolling cycle. Comparable oxygen content of the pulps will be a major point of the investigation.

2.2 Power Requirements

Conventional leach agitators, using turbines similar to ships' impellers for mixing, are high power consumers and additional power is required to compress air for sparging beneath the impellers.

Commercial Rotary Leach Vessels would require power to provide slow rotation through tires on which they would be supported and driven. Substantially lower power draft is anticipated, contributing to decreased operating costs.

2.3 Settling of Free Gold

Conventional agitators are usually started up on waste rock or low grade ore because material does build up to form a tank bottom configuration dictated by the flow pattern caused by the mixer. This build-up is notorious for trapping free gold which is not recovered until the leach vessel is out of service for repairs or milling is terminated.

Build-up would not be probable in Rotary Leach Vessels, but should it occur it would be visible as the shell emerges from the pulp during rotation.

2.4 Gravity Separation

Most gold mills use jigs, shaking tables, settling cones or some type of gravity separation unit in the grinding circuit. This is to remove fine free gold before it is allowed to enter the agitators and settle to the bottom. Also, larger gold particles require longer retention time for leaching.

It is anticipated that gold traps could be built into the discharge end of rotary leach vessels to act in place of gravity separation equipment in the grinding circuit. This concept would be considered as part of the program as it would eliminate the upstream jigs or tables which incur considerable operating costs and, tables in particular, require extensive building floor area.

2.5 Action During Power Failure

Conventional agitators usually can be re-started after power failure, provided the power outage is of short duration. However, every power failure adds to the build-up in the tank bottom as mentioned it Item 2.3 above.

Rotary Leach Vessels could settle out during power failures and still be started readily by rocking with the drive motor on-off push button.

2.6 Rotary Leach Vessels for Carbon in Pulp Circuits

Conventional C.I.P. circuits utilize separate vibrating screens or integral stationary screens for carbon advance and removal.

Since Rotary Leach Vessels are suitable for trommel screens and it is likely that rotation will be quite slow, there appears to be a good possibility that carbon abrasion would be minimal.

HATCH ASSOCIATES

3.0 SCOPE OF THE PROGRAM

Hatch Associates Ltd. will make the appropriate arrangements with a suitable Canadian testing laboratory, initiate and direct the studies and evaluate the results of the program.

3.1 Phase I: Bench Scale Investigation

This preliminary series of bench scale batch tests has been planned to investigate why the rolling bottle method has demonstrated superior efficiency when compared to the agitated beaker method.

Schedule of Work	Man-Days
a) Develop size and design of rotary leach vessel to be fabricated by testing laboratory	5.0
b) Two tests per week are planned for a period of eight weeks. Allowance for one visit per week to the testing facility for discussion, evaluation and planning	6.0
c) On completion of Phase I a comparative cost-benefit analysis will be completed. Internal Review, Assessment, Agreement	3.0
d) Develop comparative flowsheets of conventional and rotary leach vessel mill circuits	4.0
e) Prepare Draft Report, Phase I	3.0
f) Review, release Final Report	2.5
Total Man-days Phase I	23.5
Contingency	2.5
Budgeted Man-days Phase I	26.0

3.2 Phase II: Continuous Pilot Plant Operation

Should the results from Phase I so warrant, three or more rotary leach vessels would be fabricated to permit continuous operation in parallel with a conventional pilot plant continuous agitation leach circuit. A separate proposal would be prepared for this phase on completion of Phase I, if the economic indications are attractive.

3.3 Ore Samples and Supply

Grinding mill feed from one of the currently operating Canadian gold mills is the preferred material for this study. Use of this material will provide an additional check on the work by providing a commerical recovery figure on the ore sample utilized.

No difficulty in obtaining suitable test material is anticipated on approval of this proposal.

4.0 THE COMPANY BACKGROUND

Hatch Associates Ltd. offers comprehensive engineering services to the metallurgical industry. The total capital cost of major projects engineered by the company is in excess of three billion dollars. Many of these projects are "one of a kind" and are located in Canada, the U.S.A. and overseas.

Hatch Associates Ltd. is 100% Canadian, wholly owned by its staff. Since its formation in 1955, it has grown to a staff of about 450, with over 200 engineers and technologists. The head office is located in Toronto. Other offices are in Vancouver, Calgary, Hamilton, Montreal, Buffalos, N.Y. and Melbourne , Australia, with field offices in Johannesburg and Trinidad.

The process group is responsible for feasibility studies, new process development, pilot plant investigations, process design, environmental control projects and the start-up of major industrial facilities. The group consists of over 50 chemical, environmental, metallurgical and mining engineers, with many years of research development and plant operation experience. Most of the personnel in this group have advanced degrees.

The process group works closely with the design group, which is responsible for the engineering of projects. This group consists of civil, structural, mechanical, electrical and instrumentation engineers having broad experience in the design of industrial plants. Special expertise is available in bulk handling, familiarity with process equipment and dealing with large electrical loads.

4.1 Assigned Personnel

Resumes of all people assigned to this project are attached. Of particular relevance to this study are:

J.M. Hemstock

The Project Engineer has extensive experience in the design, construction and operation of gold milling facilities, extending from shiftwork as solution operator to concentrator superintendent.

H.G. McVeigh

The Project Manager has worked for many years in the testing, design, construction and supply of equipment to the mineral industry, including the general manager level of responsibility.

HATCH ASSOCIATES

PART B - MANAGEMENT PROPOSAL

5.0 PROJECT PRICE PROPOSAL

5.1 Project Team

Part A Section 3.0 "Scope of the Program" outlines the estimate of man-days expended. It indicates the project team's participation in the study will be as follows:

	Base Man-days	Contingency	Total Budget Man-days
J.M. Hemstock	12.5	+1.0	13.5
H.G. McVeigh	9.5	+1.0	10.5
A.R. Pasieka	1.5	+0.5	2.0
	23.5	2.5	26.0

5.2 Management Control

For a project of this size, a very simple management organization will be established. The key technical direction and planning will be done by the Project Engineer; J.M. Hemstock will be assigned. Man-hours spent on the job are recorded by each individual weekly and all time charged to the job must be approved by the Project Manager. This manager would be Mr. H.G. McVeigh who would also be the Associate responsible for the project.

5.3 Cost of Manpower

5.3.1 Hatch Associates Ltd.

Remuneration for the participating consultants named in Section 5.1, and support services and costs, are as follows:

H.G. McVeigh	Direction and technical consulting 10.5 days @ $583	$ 6,122
J.M. Hemstock	Technical consulting 13.5 days @ $583	$ 7,870
A.R. Pasieka	Program review and consultation 2.0 days @ $583	$ 1,166
Estimating	16 hours @ $49.88	$ 798
Secretarial	50 hours @ $26.30	$ 1,315
Other Charges -	Telex, Telephone, Copying, Mail	$ 387
Travel Expenses		$ 800
Sub-Total, Hatch Associates		$18,458

HATCH ASSOCIATES

5.0 PROJECT PRICE PROPOSAL (cont'd)

5.3.2 Ontario Research Foundation

The following budgetary estimate of laboratory expense has been reviewed with ORF and the Phase I work mutually agreed to not exceed $16,118.25 as follows:

Sr. Research Scientist	4 hours x 7 weeks @ $73.75	$ 2,065.00
Sr. Technologist	4 hours x 7 weeks @ $65.30	$ 1,828.40
Technician 1	40 hours x 7 weeks @ $26.50	$ 7,420.00
Assaying	90 Analyses	$ 983.25
Materials fabrication and supplies		$ 1,100.00
Plant surcharge	336 hours @ $8.10	$ 2,721.60
Sub-Total		$16,118.25

Total Cost of Phase I Work:

5.3.1 + 5.3.2 = $34,576.25

The total price, not to exceed, is firm for a period of 90 days from the date of submission of this proposal.

5.4 Price Certification

We hereby certify that the price quoted is based on costs completed in accordance with Costing Memorandum 1031, a copy of which we acknowledge to have received, and that the said price does not contain an element of profit, after tax, in excess of 10% of such costs.

Furthermore, we hereby certify that the attached Schedule of Rates is not in excess of the lowest rates charged any other client, including a most favoured client, for like quality and quantity of service and does not include any element of profit in excess of that normally obtained by us on services of like quality and quantity and does not include any provision of discounts or commissions to selling agents.

5.5 Method of Payment

It is proposed to invoice monthly for the time and expenses incurred on the job.

5.0 PROJECT PRICE PROPOSAL (cont'd)

5.6 Canadian Content

Our proposal is 100% Canadian content. We hereby certify that the statement of Canadian content submitted on Form DSS 9260 is true, correct and complete, and in accordance with the CGSB Standard for Definition of Canadian content.

5.7 Cash Flow and Work Plan

These items are laid out in the attached "Plan of Work and Cost". The following target dates can be met based on August 1, 1985 start-up:

Development and design of leach vessel	September 1, 1985
Laboratory testing and Process Analysis	November 1, 1985
Interim Report, including Comparative Cost Analysis	December 1, 1985
Final Report and Submission	December 20, 1985

SCHEDULE OF RATES - MARCH 30, 1985

	Per Diem	July 22/85 D.S.S.
~~Principals and~~ Senior Consultants	~~$700.00~~ *	$583.00
Project Managers		
Specialists, Supervisors and Managers	625.00	
	Per Hour	
Senior Engineers & Technologists	$ 59.76	
Intermediate Engineers & Technologists	49.88	
Junior Engineers & Technologists	37.38	
Senior Designers	51.52	
Designers	42.36	
Senior Draughtsmen	37.74	
Draughtsmen	28.28	
Purchasing Agents	55.52	
Buyers & Expediters	45.12	
Clerks & Secretaries	26.30	
Construction Management Staff	*	

* Rates to be negotiated

Expenses and Disbursements: All expenses properly incurred in connection with the project including, without limitation, reasonable travelling and living expenses, long distance telephone calls and telegraphs, reproductions, printing, special delivery and express charges and site offices for resident staff are invoiced at cost, plus 15% for administration. The use of in-house computer services is charged on an hourly basis depending on the equipment and software involved. Rates for computer equipment are: Word Processing $3.00, Basic Micro Computer $5.00, IBMXT or equivalent $7.50, HP 9000 $20.00, Audocadd $30.00, Intergraph CADD $70.00.

Invoicing and Payment: Fees and expenses are invoiced monthly payable within 30 days. Per diem rated personnel are individually named in each invoice.

Time Expended: All time expended on the assignment, whether in our office, at the client's premises, or elsewhere, is chargeable, including clerical staff engaged in the preparation of documents such as reports, specifications, etc.

Overtime: Time in excess of 44 hours per week is charged at 1 1/2 times the above rates where applicable.

Schedule Revision: The next revision of this Schedule of Rates is effective September 28, 1985.

Supply and Services Canada | Approvisionnements et Services Canada

STATEMENT OF CANADIAN CONTENT
DÉCLARATION DE LA TENEUR CANADIENNE

• Vendor to complete all 3 sections - Le fournisseur doit remplir les 3 parties

1 Company name - Nom de la compagnie: HATCH ASSOCIATES LTD.

Date: July 22, 1985

Product/Service - Produit/Service: DEVELOPMENT OF ROTARY LEACH VESSEL TECHNOLOGY FOR THE RECOVERY OF GOLD & SILVER BY CYANIDATION

Bid ref. no. - Soumission réf. n°:

DSS file no. - Dossier du MAS n°: 06SQ.23440-5-9073

CANADIAN CONTENT ESTIMATE - ESTIMATION DE LA TENEUR CANADIENNE

2

		Content - Teneur ($ Can.)
A. Canadian Content: Teneur canadienne:	1. Total Canadian Content (per CGSB Standard - see the "Definition") Total de la teneur canadienne (selon les normes de l'ONGC - voir "définition")	34,576.25
	2. Federal and provincial taxes Taxes fédérales et provinciales	– 100.00
	3. Costs related to materials, labour, services, transportation (in Canada) and overhead (including profit) Coûts relatifs aux matériaux, à la main-d'oeuvre, au transport (au Canada) et aux frais généraux (y compris les bénéfices)	= 34,676.25
B. Imported Costs: Coûts importés:	(i.e., costs of direct and indirect imports) (c-à-d. coûts des importations directes ou indirectes)	34,676.25
TOTAL BID PRICE MONTANT TOTAL DE LA SOUMISSION	(A1 + B)	

IDENTIFICATION OF NON-CANADIAN CONTENT - ETABLISSEMENT DE LA TENEUR ETRANGERE

3 Would you please identify below the principal goods and services contained in your bid that would be of non-Canadian origin
Veuillez indiquer ci-dessous les principaux biens et services de votre soumission qui ne sont pas d'origine canadienne.

Imported Goods and Services - Biens et services importés	Value - Valeur ($ Can.)	Country of Origin - Pays d'origine

Authorized Signature - Signature autorisée: A. R. McNeil

Date: July 22, 1985

Canada

DSS-MAS 9260 :5

Supply and Services Canada | Approvisionnements et Services Canada

DSS MAS 9143 3 (4/81)

CONTRACT PLAN AND REPORT FORM – FORMULE DE PROJET DE CONTRAT ET DE RAPPORT

CONTRACT TITLE – TITRE DU CONTRAT DEVELOPMENT OF LEACH VESSEL TECHNOLOGY

CONTRACTOR – ENTREPRENEUR HATCH ASSOCIATES LTD.

FILE NO. – N° DU DOSSIER	SERIAL NO. – N° DE SÉRIE
06SQ.23440-5-9073	

TASK DESCRIPTION / DESCRIPTION DE LA TÂCHE	1985 TASK DURATION IN MONTHS – DURÉE DE LA TÂCHE EN MOIS												TASK COST – COÛT DE LA TÂCHE		
	1 Aug.	2 Sept.	3 Oct.	4 Nov.	5 Dec.	6	7	8	9	10	11	12	PLANNED PRÉVU À L'ORIGINE	ACTUAL PRÉCÉDEMMENT	E.T.C. À VENIR
Develop and Design of															
Leach Vessel	3,933	807											4,740		
Laboratory Facility															
Testing & Supervision:															
1. Hatch Associates		2,691	2,691										5,382		
2. Sr. Research Scientist		1,180	885										2,065		
Sr. Technologist		1,045	783										1,828		
Technician 1		4,240	3,180										7,420		
Assaying		400	583										983		
Materials		1,100											1,100		
Plant Surcharge		1,361	1,361										2,722		
Comparative Cost Analysis			946	2,027									2,973		
Report Preparation				2,332	3,031								5,363		
PLANNED COST BY MONTH / COÛT PRÉVU POUR CHAQUE MOIS	3,933	12,824	10,429	4,359	3,031								PLAN 34,576		
ACT. PRÉCÉD. / E.T.C. BY MONTH / PRÉVISION POUR CH. MOIS														ACTUAL COÛTS RÉELS	E.T.C. À VENIR

H.G. McVEIGH, P. Eng.

Associate

Education B.A.Sc. University of Toronto, 1949 Mining and Metallurgy

Professional Affiliations Association of Professional Engineers of Ontario, designated Consulting Engineer
Canadian Institute of Mining and Metallurgy
American Institute of Mining and Metallurgy

Experience Direction and Management of the planning, design, construction and operations of heavy industrial plants the ferrous and non-ferrous mining, metallurgical and chemical industries. Feasibility studies and development of new processes. Trouble-shooting and improvements in operating plants. General Management in industry.

1973 to date Associate, Hatch Associates Ltd. Consultant to the mineral industries. Advise and assist with the evaluation, both technical and commercial, of proposed turnkey operations and modifications and expansions of existing operations. Responsible to Hatch Associates keeping abreast of the latest technological advances, world-wide, in the iron ore and steel industry, particularly as it applies to the direct reduction of iron ore. This includes mine development, transportation, concentration, induration, reduction and steelmaking.

1966 - 1972 Manager of Minerals Processing, Surface-Combustion, Toledo, Ohio. (This section of Surface-Combustion developed into the Midrex Division of Midland-Ross Corporation.)

Responsible for the setting up of an autonomous group to more efficiently exploit thermal transfer technology, which had been developed by the Research Department, as it related to the processing of ferrous, non-ferrous and industrial minerals. Involved with the engineering, construction and operations of a wide variety of commercial plants and plant sections, both nationally and internationally, some of which are:

The National Steel Pellet Plant, Keewatin, Minn.
Erie Mining Corporation, Hoyt Lakes, Minn.
Griffith Mines, Red Lake, Ontario
Hanna Ferronickel, Riddle, Oregon
Oregon Steel Mills, Portland, Oregon
Georgetown Steel Corporation, Georgetown, S.C.
Hamburger Stahlwerken, Hamburg, W. Germany
Sidbec-Dosco, Contrecoeur, Quebec
LKAB, Malmberget, Sweden
Minas del Rif, Morocco
Port Latta, Tasmania

The foregoing list required involvement in all aspects of iron ore evaluation and its conversion to a suitable product for the steel industry either in the form of an indurated oxide pellet or as direct reduced iron.

1952 - 1966 The Dorr Company, Dorr-Oliver Inc., Dorr-Oliver-Long Ltd. (Canada). Initial responsibility was as a Sales Engineer. Final responsibility was as Vice President and Director of Dorr-Oliver-Long Ltd. Responsible for the sale of process equipment into mine concentrators, mines, chemical and fertilizer plants, pulp and paper mills, municipal water and sewage facilities and pollution control equipment and systems.

Worked with the Atomic Energy Commission (both U.S.A. and Canada) in the development of processes for the recovery of uranium oxides from ores.

Participated in the development, commercial installation and operations of a wide number of Fluosolids applications which were successfully introduced into mine concentrators (both ferrous and non-ferrous) and chemical plants for the drying, oxidation and reduction of ores and chemicals.

1949 - 1952 Worked as a miner and a mining engineer for Inspiration Mining and Development Corporation, Quemont Mining Corporation.

hgmv/05/85

J.M. HEMSTOCK, P.Eng.

Consultant

Education	B.A.Sc. Metallurgical Engineering, University of Toronto, 1950
Professional Affiliations	Association of Professional Engineers of Ontario Designated Consulting Engineer, A.P.E.O. Designated Specialist, Mineral Processing and Extraction, A.P.E.O. Canadian Institute of Mining and Metallurgy American Institute of Mining, Metallurgical and Petroleum Engineers
Experience	Director of metallurgical investigations on pre-concentration, flotation, leaching, solvent extraction, electrowinning on a wide range of metallic and non-metallic ores for mining companies and financial institutions. Over 15 years operating experience in the milling of gold and sulphide ores for major Canadian mining companies including Concentrator Superintendent, Noranda Mines Limited, Noranda, Quebec.
1976 to date	Provided consulting services for the following projects: Hollinger Argus Limited, Toronto, Ontario - Metallurgical consultants during the period from June 1980 to April 1981. Extensive metallurgical investigations were directed on samples of an Ontario gold ore at the facilities of Lakefield Research of Canada Limited. Goldlund Mines Limited, Toronto, Ontario - Direction of test work on samples of an Ontario gold ore. Gravity separation amalgamation, cyanidation and flotation processes were investigated at the facilities of Lakefield Research of Canada Limited. Groundstar Resources Limited, Toronto, Ontario - Direction of testwork at the facilities of Lakefield Research of Canada Limited to establish a technical and economic comparison of gold recovery from an Ontario ore by direct cyanidation and flotation followed by cyanidation of the the concentrate. Concurrently assisted in a study of the economics of custom milling and smelting and acted on behalf of client during preliminary negotiations with custom milling and smelting organizations.

Dome Mines Limited, Timmins, Ontario - Preparation of a preliminary estimate of the capital cost required to increase the capacity of the existing gold milling facilities. Subsequently participated in a more definitive study of the project.

Western Mines Limited, Toronto, Ontario - Participated in the evaluation of a feasibility report, prepared by others, concerning a large gold prospect in Northern Ontario. Scope of work encompassed the metallurgical processing aspects and capital and operation cost estimates.

Metallgesellschaft Canada Limited, Toronto, Ontario - Assisted in the metallurgical evaluation of testwork on alluvial samples from a large placer gold deposit in the Mojave Desert. Activities included observtion of the gravity separation processes conducted at the Masero Laboratories, Palo Alto, California. Review of the metallurgical aspects pertinent to concentrating lead ore in existing milling facilities in Nova Scotia. Scope of work included a review of the metallurgical investigations previously conducted by one commercial and three government research organizations. Technical and economic studies pertained to the production of silica products from a silica orebody in northern Ontario including direction of pilot plant testwork.

Billiton International Metals, The Hague, Holland - Retained to monitor metallurgical tests, including the operation of a large scale pilot plant to evaluate the potential for production of tungsten and molybdenum from a Canadian orebody.

Watts, Griffis and McQuat Limited, Toronto, Ontario - Preliminary capital and operating cost estimates for a proposed lead-zinc flotation plant in Alaska, having a design capacity of 5000 tons of ore per operating day.

David S. Robertson & Associates Limited, Toronto, Ontario - Consultant in the metallurgical aspects of a comprehensive review of the operations of a Canadian talc mining and milling facility. Review of the metallurgical sections of a major feasibility study. The project considered the technical and economic aspects of production from two separate uranium orebodies in Labrador.

Strathcona Mineral Services Limited, Toronto, Ontario - As metallurgical consultant acted as Mill Superintendent during certain periods of the start-up of the lead-zinc flotation plant of Nanisivik Mines Limited, Baffin Island, N.W.T. Canada.

William R. Barnes Co. Limited, Waterdown, Ontario - Retained to monitor bench scale testwork conducted by the Ontario Research Foundation, Sheridan Park, Ontario. Based upon the work at O.R.F., involving the flotation of silica and iron impurities from calcite, conducted a preliminary technical and economic study relating to the feasibility of producing low silica whiting from existing product streams.

Iron Ore Company of Canada, Sept-Iles, Quebec - Independent technical and economic study of alterations to the thickening circuits at the 24,000 ton per day flotation, pelletizing and induration facilities at Sept-Iles. Also represented client in negotiations with an equipment manufacturer, regarding the development of flotation concentrate drying systems.

Agnico-Eagle Mines Limited, Toronto, Ontario - On-site review of the operation of the silver milling facilities at Cobalt, Ontario. Subsequently, study was directed at Lakefield Research of Canada Limited on mill feed and product samples with a view to possible circuit improvements.

Other projects included:

- various independent consulting assignments on the feasibility of recovering gold and uranium
- pilot plant studies involving the recovery of molybdenum from low grade ores
- review of technical and economic aspects of a sulphide ore body in Mauritania

1950 - 1976 Previous Experience:

Noranda Mines Limited - Concentrator Superintendent, Assistant Concentrator Superintendent
Quemont Mining Corporation Limited -Mill Operator
Pamour Porcupine Mines Limited - Assistant Mill Foreman
Dorr-Oliver Long Limited - Sales Engineer

Papers

"Automatic pH Control in the Concentrator of Noranda Mines Limited", C.I.M. Trans., Volume LXII, 1959

"Ball Mills Using Steel vs Pebble Mills", C.I.M. Trans., Volume LXIV, 1961

ARNOLD PASIEKA, P. Eng.

Consulting Mining Engineer

Education B.Sc., Mathematics and Physics, University of Ottawa, 1952

Professional Affiliations Registered Consulting Mining Engineer - Association of Professional Engineers of Ontario
Canadian Institute of Mining and Metallurgy
Society of Mining Engineers of A.I.M.E.

Experience Broad multi-national experience at both the corporate and operations level of the Falconbridge group of companies. Scope of experience includes corporate management for offshore production and technical services, engineering and R&D management, project evaluation/exploitation and development to production, extensive know-how in monitoring the technical and economic status of mining operations, special technical expertise in mine planning, design, practical rock mechanics, ground control and support systems such as grouted bolting and hydraulic backfill and their distribution systems.

1984 to date Consulting Mining Engineer, Hatch Associates Ltd. Provided consulting services on ground control, practical rock mechanics, mine planning and mining technology to a large copper operation in Chile, S.A.

1982 - 1984 Consulting Mining Engineer. Provided consulting services to base metal, gold and silver mines in Canada and Peru on underground mine planning, practical rock mechanics, ground control, support, project appraisal for expansion, and conceptual design of a hydraulic fill plant and its distribution system. Clients included Mines de Arcata, Peru, Brunswick Mining & Smelting, Kiena Gold Mines, Heath Steel Mines.

1965 - 1982 Falconbridge Limited - Corporate Office encompassing some 32 underground mines and 5 pits in 12 operating districts within the Falconbridge Group of Companies. Held various positions as follows:

Assistant Vice-President, Mining. Provided technical expertise and directed centralized mining, mining engineering and mining R&D.

- served as director on a number of company boards
- directed the pre-production phase of the Kiena Gold Mine to production
- extended the use of finite element and numerical modelling techniques for mine planning and mine design within the Falconbridge Group of Companies

- initiated and negotiated a royalty agreement for Stall Lake Mine with Hudson Bay Mining & Smelting
- completed evaluations of a number of first order feasibility studies on new prospects
- initiated and directed a $6 million R&D project with federal funding for a hydraulic hoisting pilot plant which projected savings of 50% in capital costs and 25% in operating costs - a production-size plant was completed in the Onaping Mine

Director of Mining Engineering & Research

- initiated and completed a number of feasibility studies on mineral properties located both in Canada and Africa
- introduced short-period blasting for reef up-dip stopping at Western Platinum Ltd., South Africa
- appraised the production, rock mechanics, mine design and ground control programs at Tara Mines in Ireland for the lenders' consultant

Chief Mining Engineer

- promoted strategic mine planning at all operating divisions
- initiated, planned, designed and helped to implement to production the first modern trackless blast hole mine in S.W. Africa
- initiated and helped to implement a comprehensive mine design and long term production program for Western Platinum
- extended the use of the D.C.F. technique for project evaluation and rating in feasibility studies of mineral prospects
- designed the surface and underground tailings fill distribution system for Mogul Mine in Ireland
- introduced cemented tailings fill in order to permit total extraction of payable ore in the pillars at Mogul Mines in Ireland.

Chief Mining Research Engineer

- introduced new and more efficient mining methods, blasting techniques, mine design and grade control to the Kilembe copper mining operations in Uganda
- re-designed a hydraulic tailing fill and compressed air systems for the five mining areas of Kilembe Mine
- studied, evaluated and minimized the rock bursting problem at Opemiska Mine

1955 - 1965	Miner, Safety Engineer, Shift Boss and Chief Mines Research Engineer at Nickel Division. Implemented and directed a comprehensive and continuing mining R&D program which included the following projects: - initiated a formal rock mechanics program for mine design and ground control - introduced cemented backfill for ground control and pillar support - designed and initiated on a production basis the INCO type undercut and fill stopping method for heavy ground in a longitudinal and transverse application - initiated and defined the flow characteristics and control parameters for hydraulic tailings fill distribution systems in deep mining - initiated and designed from grass roots an underground pilot plant for hydraulic hoisting of lump ore in vertical boreholes - implemented and directed a comprehensive R&D program including mechanization in cut and fill stopping for the purposes of improving efficiency and costs.
1952 - 1955	Inco Limited. Shift Boss in Training, Stope & Pillar Boss, and Miner.
1947 - 1952	HBM & S Co. Ltd. Diamond Driller and Miner.
1944 - 1945	RCNVR. War Service.
Awards	1984 - CIM Metal Mining Medal for "outstanding achievement and contribution in the field of mining engineering"
Further Education	C.I.L. Management Course, "Management By Objectives" Fortran 4, Computer Course, University of Toronto Mineral Economics, McGill University
Past Affiliations	Member, Prospectors and Development Association Director, Mining Industry Research Organization of Canada Chairman, Ontario Mining Association-Ground Control Committee Canadian Advisory Committee on Rock Mechanics Research National Advisory Committee for Mining and Metallurgical Research Various Mining Association of Canada sub-committees World Mining Congress - Canadian Representative

Publications

Pasieka, A.R. and Moruzi, G.A., October 1984, Proceedings of Sixth Symposium on Rock Mechanics held at Rolla, Missouri. "Evaluation of a Blasting Technique for Destressing Ground Subject to Rockbursting".

Pasieka, A.R. and Wilson, J.C., CIM Bulletin, September 1966, Volume 59, Number 653, pp. 346-356. "The Importance of High Pressure Compressed Air to Mining Operations".

Falconbridge Staff - Canadian Mining Journal, March 1968, Volume 89, Number 3, pp. 39-90. "Ground Control and Fragmentation at Falconbridge Nickel Mines Sudbury Operations" - Backfilling; Research Studies on Consolidated or Cemented Backfill; Tailings Fill Conveying Systems.

Horn, Dr. W.R. and Pasieka, A.R., October 1969. Prepared and presented to the Sixth World Mining Congress, Madrid, Spain 1970. "Technical Trends and Developments in Canadian Mining".

Espley, G.H., Beattie H.F., and Pasieka A.R., "Cemented Hydraulic Backfill Within the Falconbridge Group of Companies", CIM Bulletin, September 1970.

Pasieka, A.R., Singh, Dr. K., Fersugon, B.A., "Status of Technology and Future Technological Needs of Canadian Underground Metal Mining." Seminar re Forecasts of Mining and Metallurgical Technology, Ottawa, November 1979.

Pasieka, A.R. and Sotirow, G.V., "Planning and Operational Cutoff Grades Based on Computerized Net Present Value and Net Cash Flow" - 86th CIM, April 1984.